I. C. 6979 December 1937

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

ELECTRIC SIGNALING SYSTEM, ROSS SHAFT, HOMESTAKE MINING CO.

RECEIVED
O. S. U. LIBRARY

BY

JOHN F. WIGGERT

AFTER THIS REPORT HAS SERVED YOUR PURPOSE AND IF YOU HAVE NO FURTHER NEED FOR IT, PLEASE RETURN IT TO THE BUREAU OF MINES, USING THE OFFICIAL MAILING LABEL ON THE INSIDE OF THE BACK COVER.

I. C. 6979.
December 1937

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

ELECTRIC SIGNALING SYSTEM

ROSS SHAFT, HOMESTAKE MINING CO.[1]

By John F. Wiggert[2]

HISTORY

The first signal system used in the Homestake mine between the cagemen and hoisting engineers was a mechanical one. It consisted of small cables or jointed steel rods hung in the cage compartments and counterbalanced with weights or springs. These cables or rod strings were connected to the mechanically operated gongs at the engineers' positions by means of bell cranks and steel wires. At the various stations the bell lines were also fitted with bell cranks and connected levers, so that the cagemen could operate the bells from the stations when they were handling rock or other material and not riding on the cages.

Such a system was inherited from the days before extensive electrical development. It served quite well for shallow shafts, but for depths of a thousand feet or more it was very slow and cumbersome. It required considerable muscular effort to operate it quickly, because of the inertis of its great weight and also because of frictional resistance. The maintenance cost was quite high because of the many wearing parts.

The first electric signal installation for shaft work at the Homestake was made in 1916. It replaced a mechanical system and was quite simple. It consisted of a single pair of wires in galvanized-steel conduit in each hoisting compartment. At each station the conduit and wires were connected to the pull switches. The switches were operated by means of small, galvanized-steel wire cables which extended from station to station. In series with the cables were short sections of chain. The chain was used at the stations to make it easier to pull the bell line; it was used at the bottom ends of the cables to hold them straight. The bells were single-stroke and operated on 110-volt alternating current.

---

[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6979."

[2] One of the consulting engineers to the Bureau of Mines and chief electrical engineer of the Homestake Mining Co.

Original from THE OHIO STATE UNIVERSITY

This system was a great improvement over the mechanical ones and the maintenance cost was much less because there were very few moving parts. It was fast and easy to operate, but it had a serious drawback, which applied to the mechanical system also, in that the engineer had no clue as to where a signal originated. An accident could happen if the engineer moved the cage or skip on a signal made by someone other than the cageman.

The shaft in which this system was installed has since been abandoned.

In 1921 an improved electrical signaling system was installed in another shaft of the Homestake to replace a mechanical one. This system has an annunciator incorporated with the bell for each cage or skip compartment. The annunciator is on the engineer's platform and has a number for each pull-switch station, so that the engineer has a visible and positive indication of where a signal originates. This indication greatly minimizes the possibility of a false signal causing an accident or other trouble.

In this annunciator system the shaft wires are mostly in the form of submarine cables, consisting of rubber-covered wires protected by galvanized-steel wire armor. The cables terminate in junction boxes, from which wire extensions run to the switches in galvanized-steel conduit.

After 1921 several secondary shafts were constructed which were equipped with annunciator-type signaling systems. In these shafts the signal wires are in galvanized-steel conduit.

All of the annunciators are so equipped that the engineer can automatically reset the numbers of the stations signaling. He does this by moving a device attached to the hoist control lever, which operates the reset switch.

Of course, it is much more expensive to install an indicating type of signaling system than one without annunciators, because it requires an individual wire (a ground or common wire return assumed) for each switch station.

Ross Shaft Signaling System

General Description.- This signaling system probably ranks among the best in the world for deep shafts. It is the latest development of many years of shaft-signaling experience in the Homestake mine and was installed at the time the shaft was constructed. The shaft began operating late in 1934.

This system is the same in principle as the earlier annunciator type installed by the company, but it includes a number of improvements.

The ore hoist has a separate and distinct system of cable, conduit, and wiring for each of the two skip compartments. The reason for this

Digitized by Google Original from THE OHIO STATE UNIVERSITY

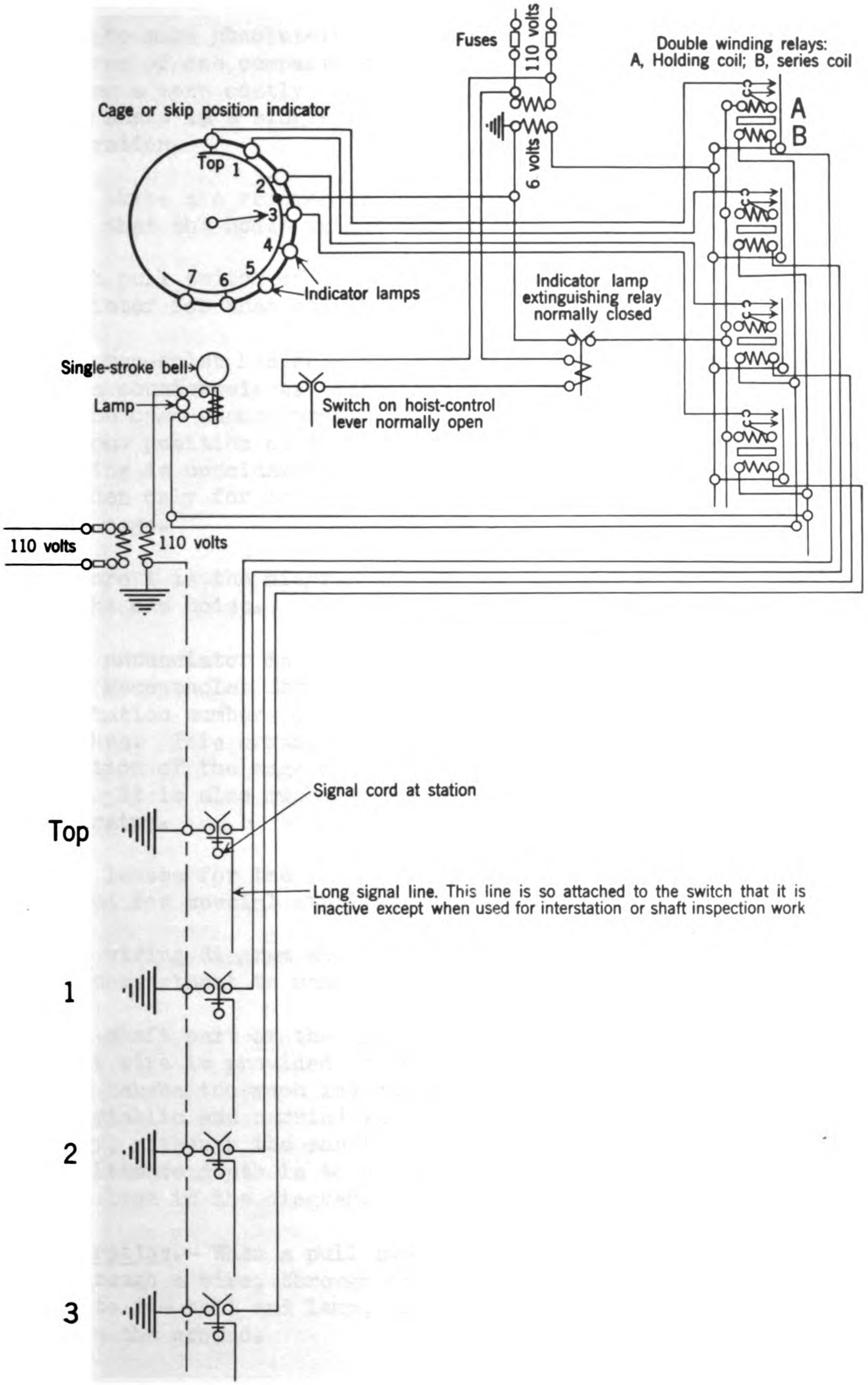

Figure 1.—Electric signalling system, one-compartment Ross ore hoist.

separation is to make absolutely impossible an accidental contact between any of the wires of one compartment and any of those of the other. Obviously, it necessitates a more costly installation than would be required were all wires for one shaft in a single cable system, but it greatly increases the safety of operation.

The skips are removed and cages used with the ore hoist during the time each day that the hoist is not used for hoisting ore.

Each pull switch of a compartment of the ore hoist has a position on the annunciator for that compartment.

The man-hoist has only one signal wiring system because it has only one cage and a counterweight. Each cage pull switch of this hoist has a position on the cage annunciator. All the counterweight pull switches are connected to one position on the annunciator for the counterweight. A single system of wiring is considered safe for the man-hoist because the counterweight is ridden only for inspection and on slow bells, and at such times no one is on the cage.

Figure 1 is the diagram for wiring the signal system for one compartment of the ore hoist.

The annunciator is part of the skip or cage-position indicator. The miniature receptacles for holding the indicating lamps are placed radially outside the station numbers or names and correspond to the respective stations or pull switches. This arrangement is convenient, as the engineer can see both the position of the cage or skip and the origin of a signal without moving his eyes. It is also much cheaper than having the annunciator a separate piece of apparatus.

The lenses for the lamps are usually opal, but sometimes other colors are used for special stations.

The wiring diagram shows connections for only four of the many stations of the compartment to make it easier to follow.

The shaft part of the system is operated with a ground return. A return circuit wire is provided in the cables and conduits, so that if the ground return causes too much inductance at great depth the entire circuit can be made metallic and carried in the same sheaths; but so far that has not been necessary, although the shaft is being operated down to the 3,800-foot level. The ultimate depth is to be 5,200 feet. The return wire is indicated by the broken line in the diagram.

Operation.- When a pull switch is operated, a circuit is closed from the ground through a wire, through one winding of a relay, then through one of two wires to the bell and lamp, and finally through the secondary of the transformer to the ground.

The first impulse caused by a switch will close the relay connected with it. When a relay closes, it locks itself in that position through a contact and second coil on it. When a relay closes, it lights the indicator lamp connected with it through a second contact on the relay.

The object of having the relay lock itself in the closed position is to keep its lamp lighted until the engineer chooses to extinguish it. He can easily do so by operating a device attached to the hoist control lever. When this device is operated it closes a contact that operates a relay, which, in turn, opens the relay holding circuit and the relay contacts.

The bell sides of the relay coils in series with the pull switches are connected alternately to one of two wires that at present are connected as a single wire to the bell. The object of the two-wire connection is that if electrostatic capacity or leakage of many long wires causes sufficient current to flow to interfere with the bell its coil can be wound with two windings differentially connected to eliminate such interference. So far, however, no trouble has been caused, although the system is working down to 73 percent of the ultimate depth.

Signal Ropes.- The wiring diagram (fig. 1) shows two pull ropes attached to each switch. One of the ropes is very short and the other long enough to reach down to the next switch.

The long rope consists of small, galvanized-steel cable with a chain insert at the switch and chain at the lower end. This rope is used for inter-station and shaft-inspection work only. It is attached to the switch, so that it does not move when the short rope is pulled. The maintenance of these ropes is a small item of expense, because they are used very infrequently. A few of them have been torn out by being caught by a cage or skip.

The short ropes are only long enough to be reached easily by the cageman when the cage is at the station. They are of manila rope and attached to the switches with harness snaps. These ropes are short and light and very easily manipulated; the cagemen transmit their signals with them with almost the speed of Morse telegraphers.

Pull Switches.- The switches are housed in strong cast-iron boxes, and the switch mechanisms are ruggedly built. The insulating parts are of bakelite and provide long creeping distances so that moisture, within reason, does not cause appreciable leakage. The switch mechanisms are held in position in the boxes with only one bolt, so that they can be replaced easily.

Summary.- All of the electrical shaft-signaling installations used by the company are very satisfactory, and the maintenance cost is moderate.

Rubber-covered wire in steel conduit does not last as long as rubber-covered wire in the form of submarine cable. Some of the wire in conduits has been replaced with new wire, but none of the cable has developed any faults.

Original from THE OHIO STATE UNIVERSITY

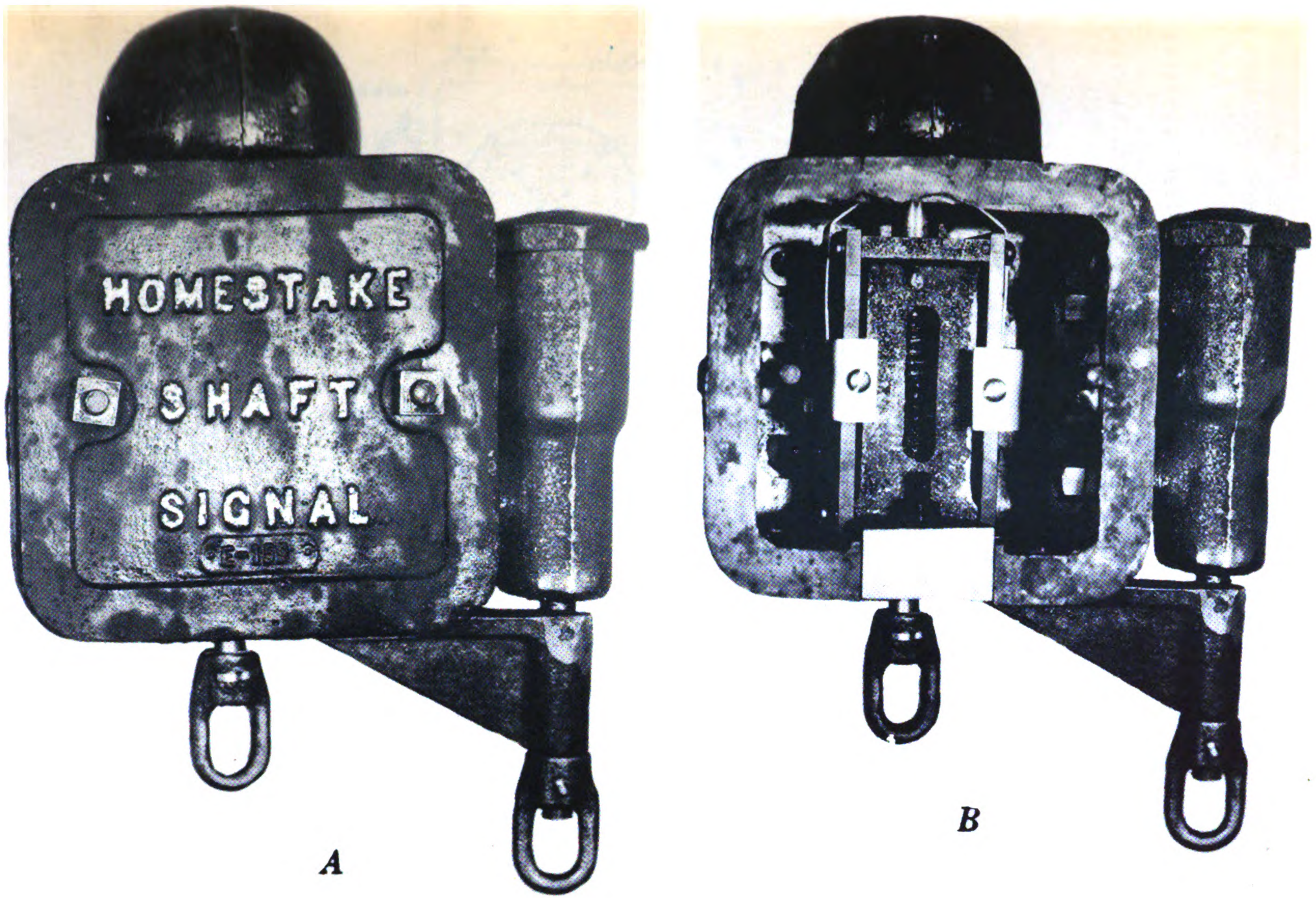

Figure 2.—Pull switch. *A*, Closed; *B*, cover removed.

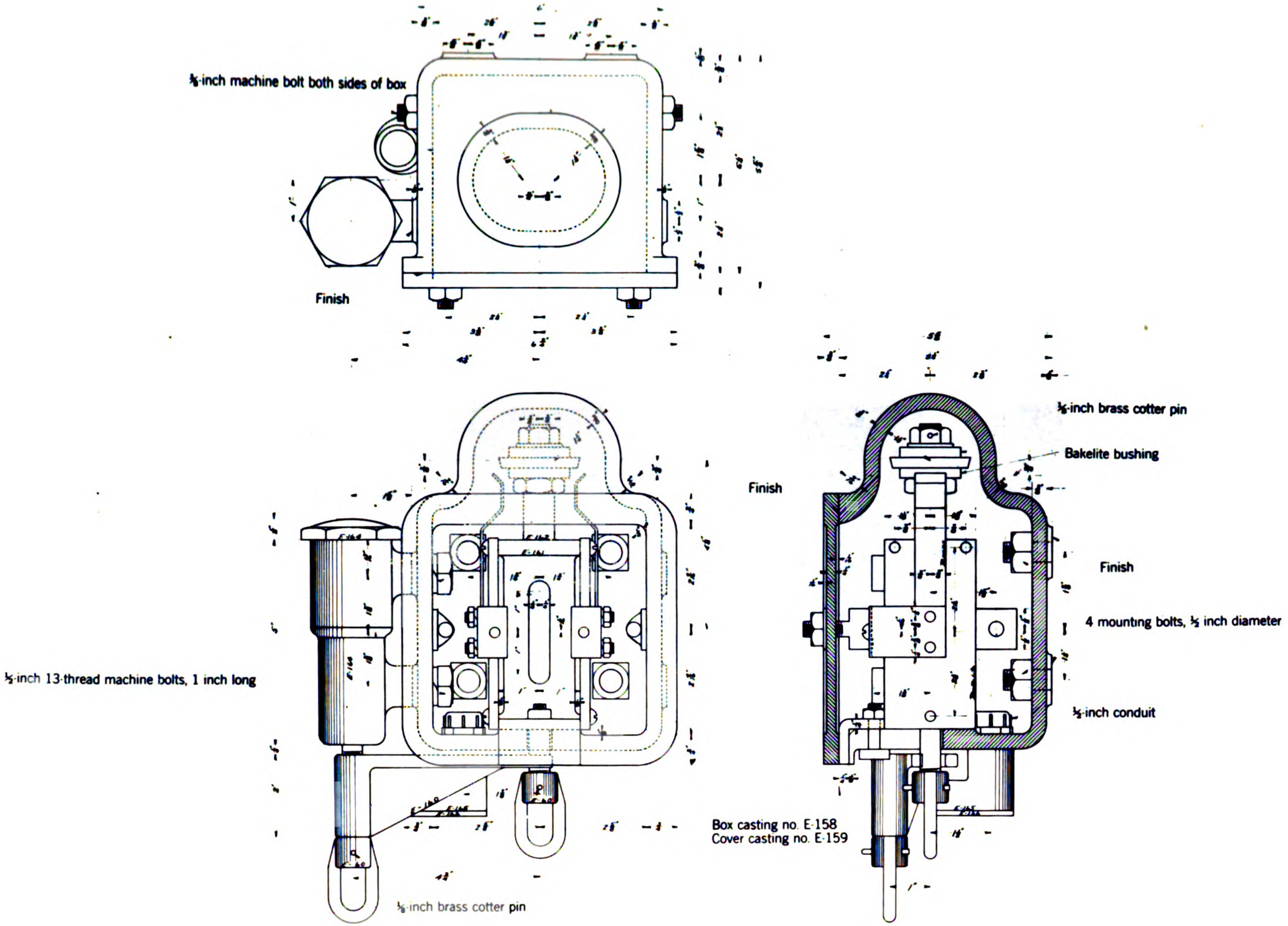

Figure 3.— Assembly Ross shaft signal switch.

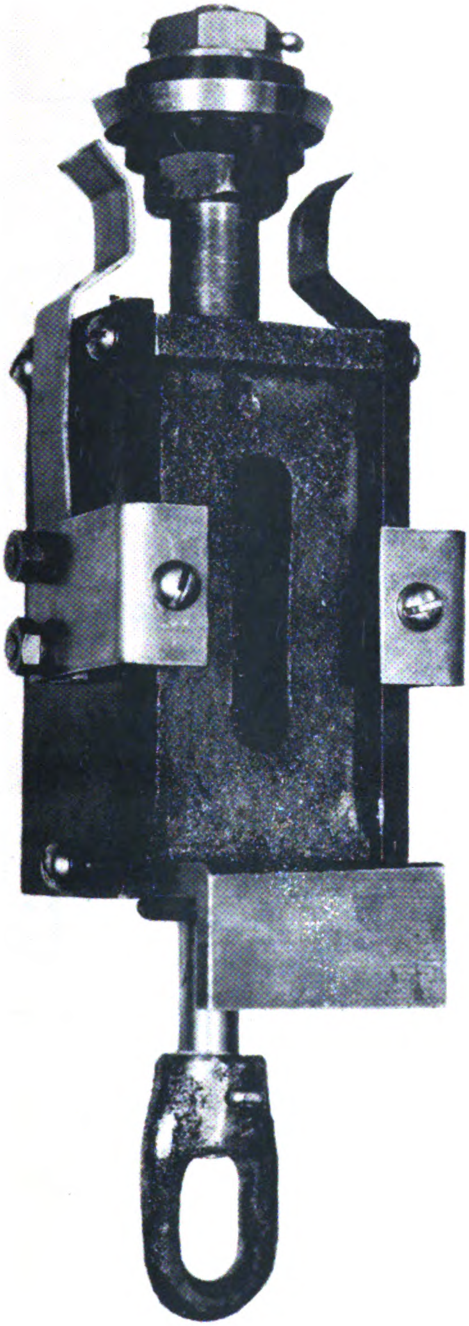

Figure 4.— Switch mechanism.

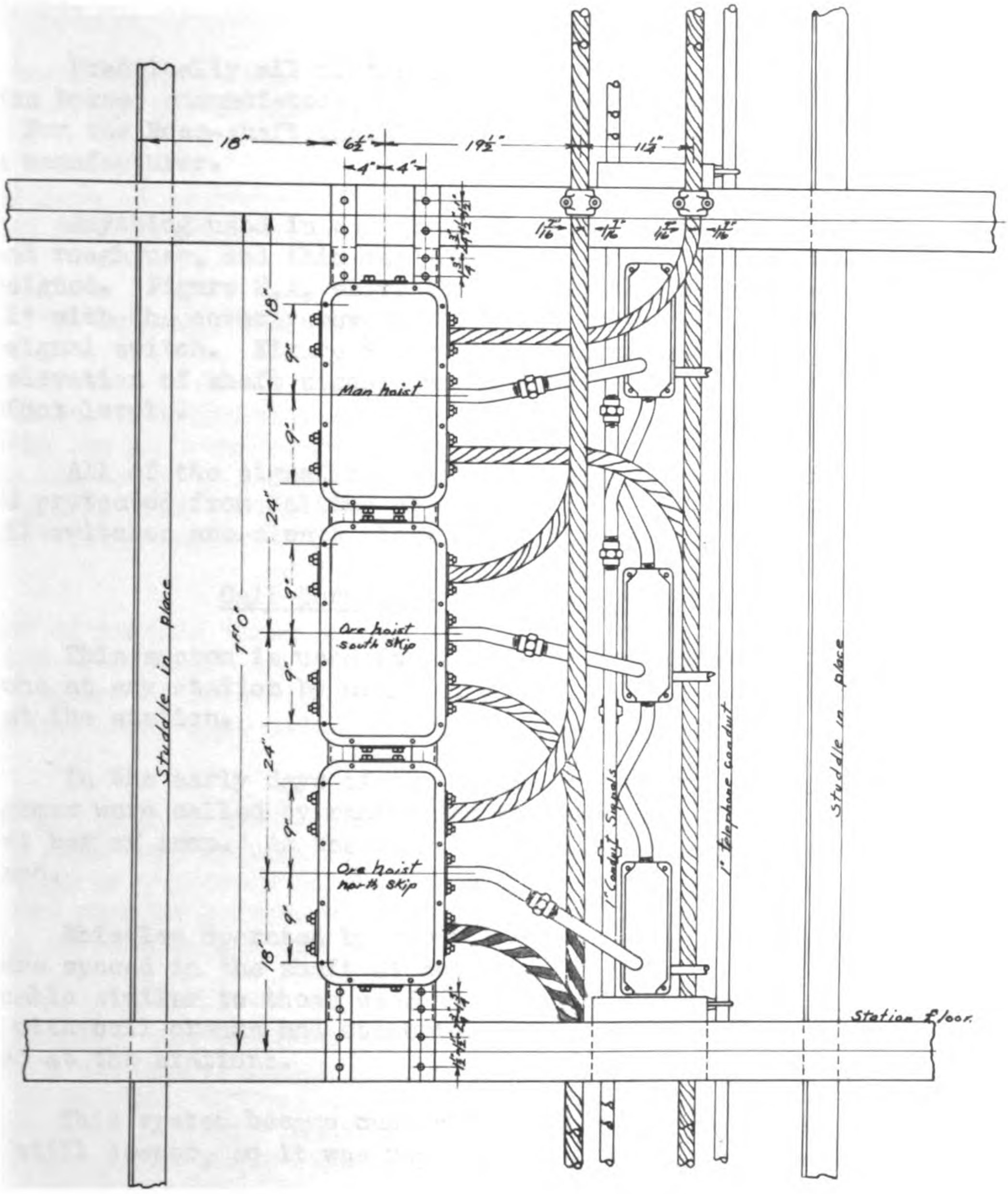

Figure 5.— Front elevation of shaft signal junction boxes for 2,000 - 3,200 and 4,400-foot levels.

The cable wires have no braid over the rubber. They are cabled together, than covered with weatherproof braid, and over the braid is a galvanized-steel wire armor.

Practically all of the apparatus, such as switches, switch boxes, junction boxes, annunciators, and bells, was designed and built by the company. For the Ross-shaft installation the relays and bells were purchased from a manufacturer.

Anything used in a mine shaft needs to be of rugged construction to stand rough use, and this was taken into consideration when the apparatus was designed. Figure 2,A, shows the pull switch box closed and figure 2,B, shows it with the cover removed. Figure 3 shows the assembly of the Ross-shaft signal switch. Figure 4 shows the switch mechanism and figure 5 a front elevation of shaft signal junction boxes for the 2,000-, 3,200-, and 4,400-foot levels.

All of the signaling apparatus in the shaft is arranged so that it will be protected from falling objects as much as possible. For instance, the pull switches are always close under the divider timbers or beams.

Call-Horn System in the Ross Shaft

This system is used for signaling the cagemen. It can be operated by anyone at any station by means of a pull switch located in a convenient place at the station.

In the early days of the Homestake, before the mine was very deep, the cagemen were called by rapping on the air pipe at the shaft with a hammer or short bar of iron. As the mine became deeper, this method had to be abandoned.

Whistles operated by compressed air were then used for a long time. They were spaced in the shaft at suitable distances, and were operated by a steel cable similar to those used to signal the engineers. The cable was fitted with bell cranks and connected levers so that the whistles could be operated at the stations.

This system became cumbersome and costly to maintain as the mine became still deeper, so it was replaced by electric horns.

The electric-horn system has been used in all of the shafts of the Homestake for many years and is very satisfactory.

The following description pertains particularly to the system in the Ross shaft, although those in the other shafts are similar except that they are not designed for as great a depth.

The horns are placed in the shaft at intervals of 100 feet from the surface down to and including the 1,100-foot level. Below that they are

Original from THE OHIO STATE UNIVERSITY

located at every level, and those levels are 150 feet apart. The horns are so situated that they are protected from objects falling in the shaft. Horns are so placed at stations that they can be reached without entering the shaft if repair or inspection is necessary.

The horn cases are made of cast iron and are so constructed that they serve also as junction boxes for the conduit and wiring system. They have knobs in them for holding the vertical wires.

The pull switches are located out on the stations in readily accessible places. They are the same kind of switches as those used for shaft signaling.

The wiring system consists entirely of rubber-covered wires in galvanized-steel conduit.

All of the apparatus, including the horn mechanisms, was designed and made by the company. In its design careful consideration was given to details that are essential to the successful operation of apparatus used for such severe service. It was intended to make all joints watertight, but with so many joints it is practically impossible to prevent some water from entering, so the horn boxes are provided with drain holes.

All of the horn boxes are equipped with small heaters to keep the air in them slightly warmer than the surrounding air. The air in the mine is so humid that the delicate coils for the horns would soon be damaged by moisture if the air surrounding them were not kept quite dry. Each heater consumes only 6 watts (0.055 ampere), at 110 volts.

Figure 6 is a connection diagram for the horn system. At present it receives its power at the top end, but it is expected that when the shaft reaches its ultimate depth of 5,200 feet it may be necessary to supply the power to the system at its midpoint to prevent excessive voltage drop. Horns are now operating down to the 3,800-foot level, and the service is quite satisfactory.

The fourth wire, shown dotted in the diagram, was installed as a precautionary measure, so that if the number of horns became too great to operate on one circuit they could be operated on several circuits by means of relays operated by this fourth wire. Experience seems to indicate that the fourth wire will not be required for the shaft depth contemplated.

The conductors used were the smallest that careful calculations indicated as practicable for the service. The idea, of course, was to keep the installation cost as low as was consistent with good operation. It was impossible to calculate the inductance of such circuits exactly, so the fourth wire, which is small, was installed as a way out if the impedance encountered in practice with large current became too great.

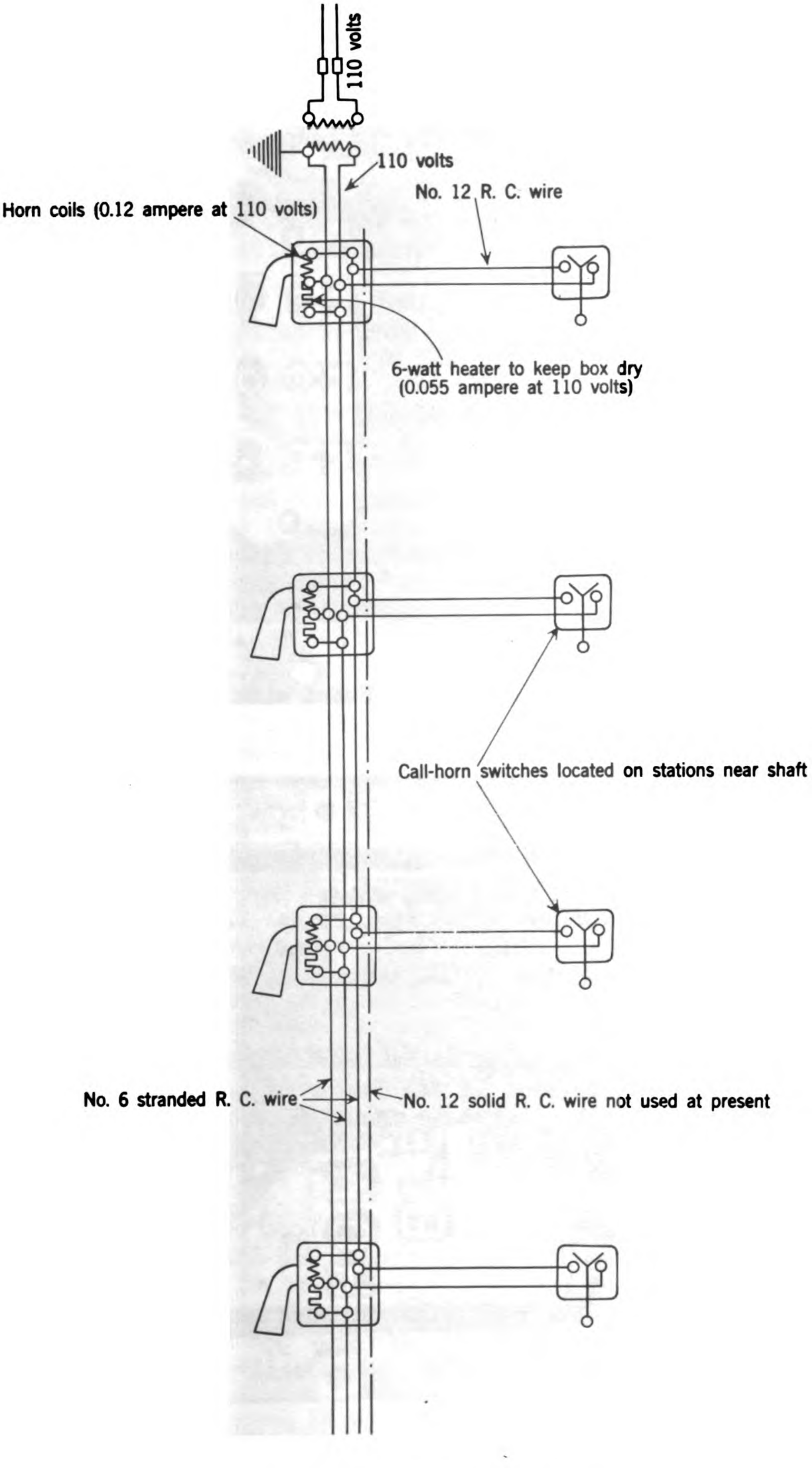
110 volts
110 volts
No. 12 R. C. wire
Horn coils (0.12 ampere at 110 volts)
6-watt heater to keep box dry (0.055 ampere at 110 volts)
Call-horn switches located on stations near shaft
No. 6 stranded R. C. wire
No. 12 solid R. C. wire not used at present

Figure 6.—Call-horn system for the Ross shaft.

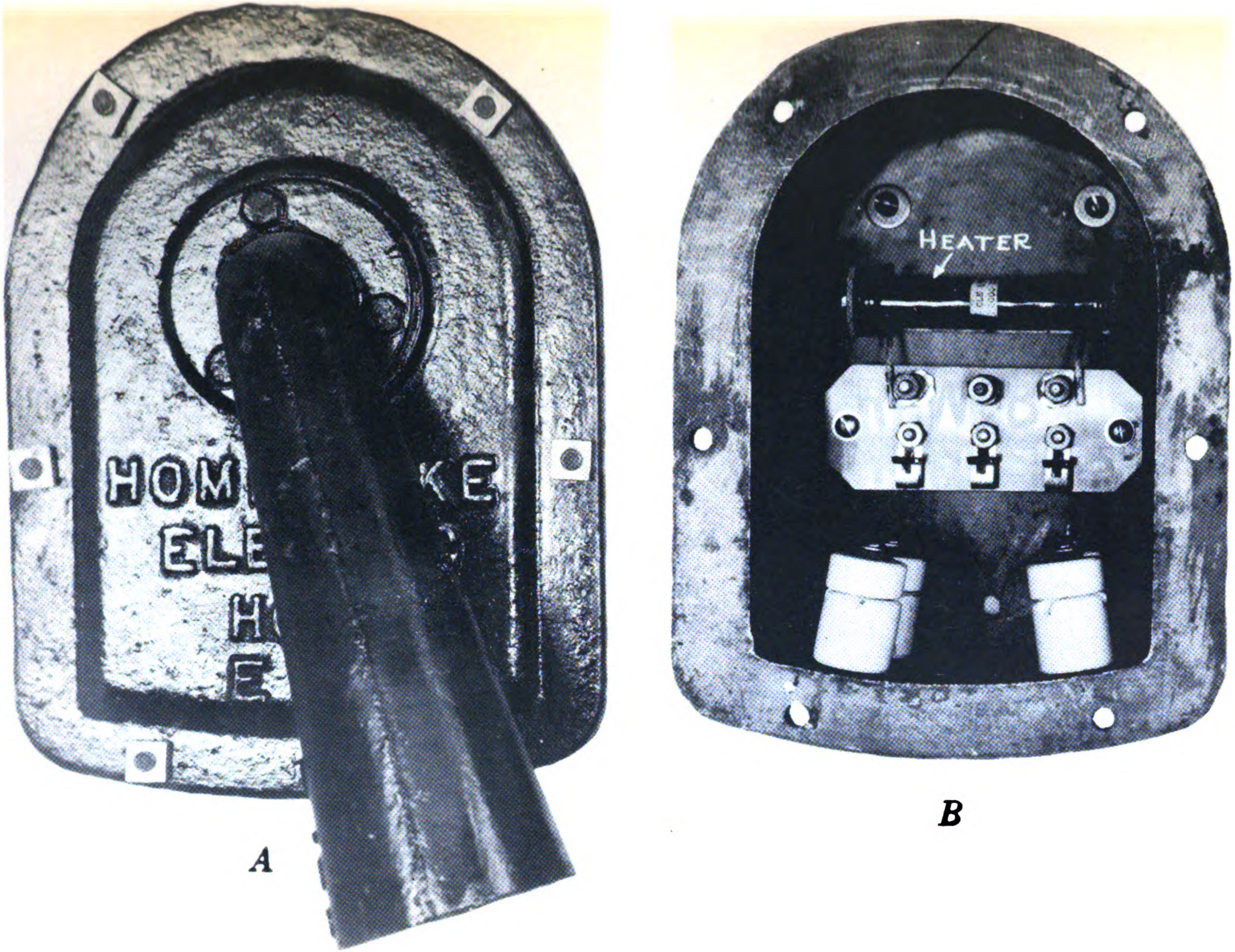

Figure 7.—*A*, Call horn; *B*, inside view of horn box.

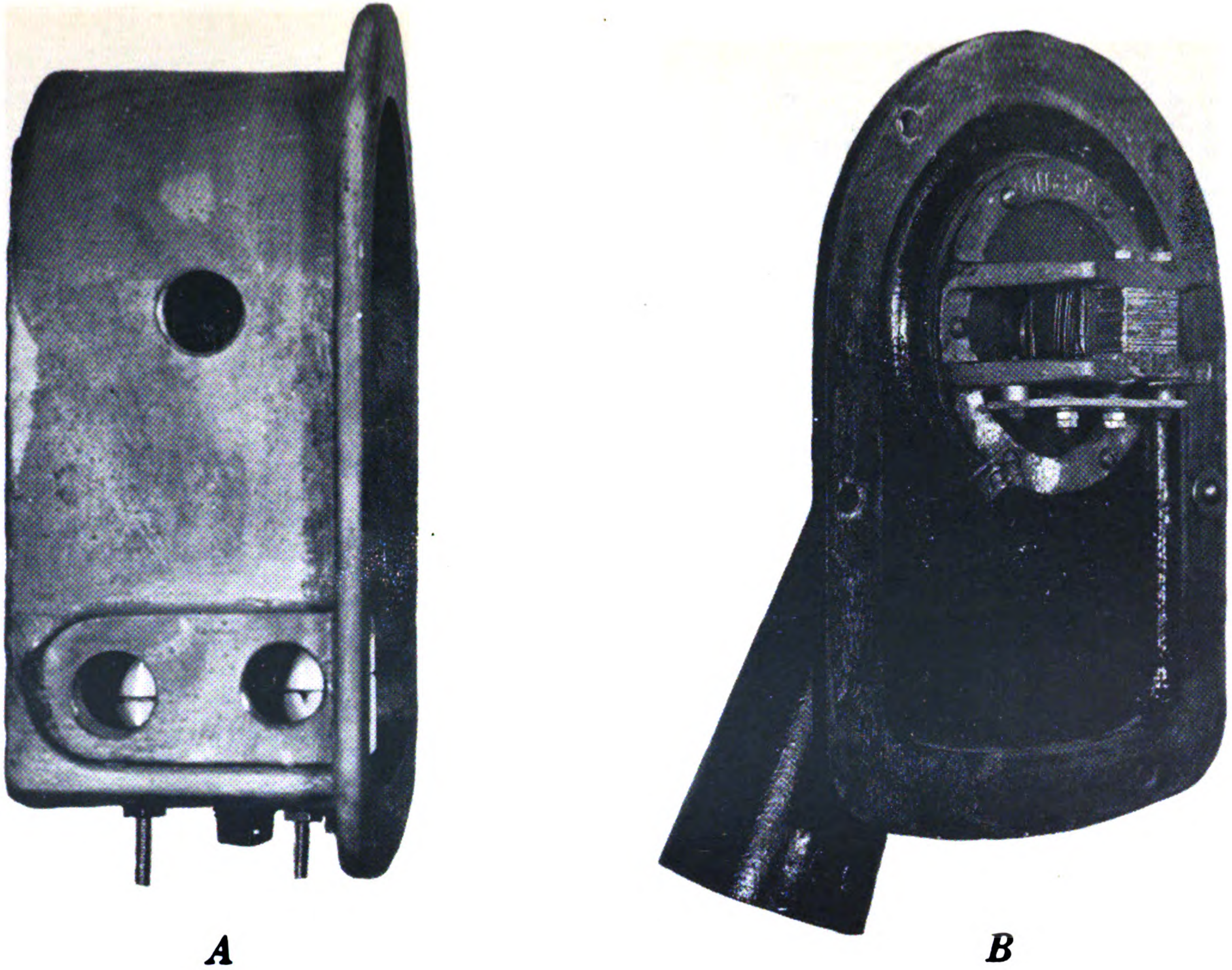

Figure 8.—*A*, End view of horn box; *B*, horn mechanism.

The actual experience with the shaft operating down to 73 percent of its ultimate depth of 5,200 feet indicates that the fourth wire will not be necessary. It is possible to increase the capacity of the system greatly by feeding the power to it at about its midpoint, as mentioned.

The maintenance expense of the horn system is very low, the principal cost being on the replacement of horn diaphragms. They fail or break, due to crystallization caused by vibration. When a horn unit fails to function it is replaced by a repaired or new unit and is taken to the shop for repairs. The change is accomplished easily because the mechanism is attached to the cover and it is only necessary to remove a few bolts and disconnect three flexible wires from Fahnestock binding posts.

The third wire is a ground connection to the cover so that the workman will not receive a shock from handling the cover and attached mechanism while changing units if one is grounded to a live part.

Figure 7,A, shows the call horn and figure 7,B, an inside view of the horn box. Figure 8,A, is an end view of the horn box, and figure 8,B, shows the horn mechanism.